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CHEMICAL CHANGES DURING THE RIPENING OF SUGAR CANE

By JOSE MIRASOL Y JISON.

Thesis presented for graduation from the College of Agriculture No. 34.

INTRODUCTION.

The present paper is a study of the chemical changes occurring in ripening sugar cane. Since the experiment was performed with local varieties the data obtained are chiefly of local value, nevertheless it is believed that the results are of interest as confirming facts already known concerning the loss of crystallizable sugar in cane not harvested at the proper season.

Three varieties of cane were selected for analysis with a view to comparing their merits. These were the second generation of those introduced into the College farm by Mr. Adriano, and bear the following college numbers: 1834 V-I, Sinanduyong; 1835 V-I, Zambales white; and 1836 V-I, Los Baños white or the white Bamboo Cane. In his Thesis published in the Philippine Agriculturist and Forester (Vol. III No. 2) Mr. Adriano mentions the origin and characteristics of these varieties. The yield per hectare, as he computed, it during the first year, was as follows:

	1834 V-I	1835 V-I	1836 V-I
Number of canes	49547	44035	82250
Weight of cane (Ton)	25.69	50.70	63.63

These yields seem to be lower than those obtained in Negros. But it must be understood that the College farm is the site of a very old plantation continuously planted to sugar cane, corn, and rice without any at-

tempt at fertilization. Scant rainfall and shallow soil might be mentioned as other unfavorable factors. In Negros the soil is alluvial and the rainfall quite uniform throughout the year, but in the College one often finds adobe rock at a foot below the surface, while the rainfall is scarce, 26.66 inches being that recorded from January to December 1914.

1834 V-I, Sinanduyong was planted March 3, 1914 in a plot previously occupied by Mr. Camus' experiment, "Field Tests of Corn". A full account of the treatment of the plot is published in "The Philippine Agriculturist and Forester" (Vol. III No. 8.). 1835 V-I Zambales white was planted March 6, 1914, in two rows in a plot previously planted to Manihot utilisima (Camoting cahoy). 1836 V-I was planted March 8, 1914, in three rows in the same plot side by side with the Zambales white.

CHEMICAL CONSTITUENTS OF SUGAR CANE.

There are two groups of sugars in the sugar cane, cane sugar (sucrose or saccharose), and reducing sugars. The second group includes two kinds of reducing sugar technically known as dextrose and levulose, which are formed by the inversion of sucrose. In the factory the reducing sugars are sometimes called glucose, or invert sugar.

When it became known that plants elaborate their food in the cells of the leaf it re-

mained for botanists and physiologists to trace and identify the resulting product. Investigations led to the identification of a carbohydrate. Sachs' (4) view was that this carbohydrate is starch, but Brown and Morris working with *Tropaeolum majus* (Indian cress) have demonstrated that sugar is formed before starch, and they further indicated that this sugar is cane sugar. Freeman, (4) in his paper "Note on the formation of cane sugar in the Sugar Cane" adopted the conclusion of the latter investigators. Finally Went (5), studying the physiology of the cane, corroborated the results of Brown and Morris. Thus the fact is established that cane sugar is the first visible product of assimilation.

This process of food elaboration occurs in the presence of light, and with increased intensity of the light the formation of the cane sugar is increased. The sucrose in the leaf is inverted into dextrose and levulose and used in the upbuilding of the tissues. The excess is deposited around the cellular vessels in the form of starch. This starch, however, is again dissolved at night and transferred to the stem in the form of glucose. Sugars in leaves of different ages behave differently. According to Went's (5) investigation sucrose coming from a young leaf to the stem at its top is inverted when it reaches that place, and that which comes from an old cane reaches its destination without undergoing any change.

The sugar in the cane accumulates in joints. During the entire vegetative period Went (5) noted the following changes: At the moment the joint is formed, it contains nothing but starch, which is gradually consumed in the formation of fiber. At this time also the leaf attached to the joint begins to assimilate. The sugar collects and the joint grows. Sucrose is inverted, but dextrose and levulose remain unchanged. A portion of the reducing sugar is carried up to the young joint above and the other portion is used up during local growth for the formation of the fiber. This transformation and transposition goes on constantly, and by the time the joint reaches the adult stage it contains much reducing sugar and very little saccharose. At this time, however, no more inversion takes place in the transported sucrose, meanwhile the glucose is consumed by respiration, so finally the sugar in the joint becomes mainly sucrose. Fully matured tropical canes frequently contain no more than traces of reducing sugars.

Beside the sugars many other chemical compounds are found in the sugar cane. The juice is in itself an admixture of organic and inorganic substances held either in solution or in suspension. The fiber constituting the bulk of the bagasse is found to contain ash, fat, and wax, protein, cellulose, a pentosan, and lignin. Deerr (3) gives as limits of the composition of a single cane the following: Water, 69 to 75%; Saccharose, 7 to 20%; Reducing Sugars, 0 to 2%; Fiber, 8 to 16%; Ash, 0.3 to 0.8%; Organic non-sugar 0 to 1%.

Variety is not the only factor that influences the saccharine content of cane. It is also influenced by climate, age, character of the soil, conditions of cultivation, condition of the atmosphere, insect pests, and fungus diseases.

In subtropical countries, where frost shortens the period of vegetation, sugar cane is harvested immature, and consequently the sucrose content of the cane is low. In some parts of Hawaii and Peru, where precipitation is low, the canes stand in the field as long as 20 months and the sugar content reaches as high as 16%.

Age greatly influences the sucrose content of the cane. As has been found in this experiment, young canes contain little sucrose, over-ripe canes also contain less than perfectly ripe ones, because of the inversion of sucrose. A shower on the ripening cane diminishes its sucrose content but does not effect the purity. Heavy soils as a rule yield sweet canes. In the West Indies it has been found that ratoon crops give juice superior to that of the planted canes, but the yield diminishes every year.

The attacks of the insect pests and fungus diseases prove quite deleterious to the sucrose content of the cane. Sound canes always contain higher percentages of sucrose than canes attacked by insects or diseases. Attacks of cane borers cause the sucrose in the cane to fall, while infection with pineapple disease causes an increase of glucose. In Hawaii the leaf hopper is a great enemy of the planter. It was found to cause a loss of as much as 15% of the sucrose in the cane. Leaf hoppers are also very common in the Philippines, but, curiously enough, no account is ever taken of them. The locust also causes considerable damage to sugar cane in the Philippines.

CHANGES IN THE CANE DURING RIPENING.

We have just reviewed the vegetative life of a single joint, and are now ready to follow the development of the whole plant. The entire plant is made up of a series of joints, and its life history is the formation and growth of

these joints. Experiments to determine the composition of the cane, at different period of life have been repeatedly made in various sugar countries. In Louisiana, Java, and the West Indies these experiments gave only one general result; namely, that the chemical composition of the cane is not the same at all stages of growth. The farmers in the Philippines are probably well aware of this fact, and an attempt to repeat such an experiment here would seem unnecessary were it not that with our present method of milling cane and manufacturing sugar some unnecessary losses could be avoided by demonstrating that there is a proper time for harvesting cane, which may be determined by chemical analysis and which need not be the same for different varieties.

In cane one meets all degrees of variation and a representative sample is therefore most difficult to secure. Sampling by definite weight, says Hall (1), will give fairly accurate results, but the possibilities of considerable variation in the stalks, due to differences in size and maturity, make the method undesirable. Sampling by taking a definite number of stalks selected by hand is objectionable also for the influence of an unconscious desire to choose the best stalks leads to higher results. However, a long series of trials in an attempt to secure a representative sample at the Tacuman Experiment Station (1) shows that the latter method may be made to give dependable results. In our experiment, therefore, this method was used.

The sample was taken at random, great care being exercised not to lose the adhering trash. The cane was weighed, then cleaned and topped, and the percentage of stripped cane calculated. The canes were brought into the Laboratory and passed twice through a hand mill (Pioneer cane mill, No. 2). The brix of the juice was taken, the latter clarified by a solution of sub-acetate of lead, and polarized according to the method of Schmitz. The bagasse was also weighed in order to find the extraction by weight and the fiber and sucrose determined. The invert sugar in both juice and bagasse was determined by the Munson and Walker method (9), slightly modified, acetone being used instead of alcohol and ether for the washing of the cuprous oxide collected on the Gooch crucible. Purity, fiber, sucrose, invert sugar, and the extraction of sucrose per 100 parts sucrose in cane were calculated. The crystallizable sugar was computed from the formula of Geerligs, $C = S(1.4 - \frac{40}{P})$, based upon

the assumption that each part of solids not sucrose prevents four-tenths of a part of sucrose from crystalizing.

The following tables (I, II, and III) show the results of analyses by the writer of the three varieties grown at the College.

TABLE I.—VARIETY ZAMBALES WHITE

Date	Age	Weight 100 stripped canes.	Kilos stripped cane per 100 kilos cane & trash	Kilos juice per 100 kilos strip- ped cane	Juice (Determined)				Bagasse (Determined)				Cane (Calculated)				Sucrose extrac- tion by hand-mill.
					Corrected Brix		Purity %	Inv. Sugar %	Sucrose %	Inv. Sugar %	Fiber %	Fiber %	Sucrose %	Inv. Sugar %			
					Sucrose %	Sucrose %											
Aug. 21, 1914	5 mo. 28 da.	85.0	58.62	64.70	8.70	2.96	35.44	1.21	2.58	0.27	31	10.90	2.80	0.97	0.70	67	
Sept. 21, 1914	6 mo. 18 da.	107.5	64.18	74.42	9.70	4.66	48.04	0.84	4.47	0.73	34	8.60	4.61	0.82	1.80	75	
Oct. 15, 1914	7 mo. 12 da.	142.5	67.05	71.71	11.62	6.92	59.55	0.86	5.90	0.67	35	9.80	6.63	0.81	4.60	75	
Nov. 2, 1914	7 mo. 29 da.	162.5	69.82	72.54	13.42	8.55	63.71	0.69	7.73	0.28	38	9.90	8.32	0.57	6.60	72	
Nov. 24, 1914	8 mo. 21 da.	175.0	74.46	67.14	15.71	11.42	72.69	1.51	9.57	0.77	36	11.80	10.81	1.20	9.60	72	
Dec. 8, 1914	9 mo. 5 da.	165.0	68.75	72.72	16.08	13.34	82.96	1.51	9.51	0.78	37	10.00	12.29	1.30	12.20	78	
Dec. 29, 1914	9 mo. 26 da.	170.0	71.57	69.12	15.25	12.96	79.83	1.62	11.31	0.77	35	10.80	12.45	1.32	11.50	72	
Jan. 12, 1915	10 mo. 8 da.	170.0	73.90	65.00	16.40	13.15	80.18	1.33	10.43	0.83	36	11.60	12.28	1.48	11.70	69	
Jan. 27, 1915	11 mo. 5 da.	173.0	72.00	69.00	16.21	12.53	77.23	1.42	10.06	0.87	35	10.80	11.90	1.80	11.00	70	
Feb. 10, 1915	11 mo. 15 da.	167.5	71.00	67.00	16.20	12.34	77.58	1.73	9.34	0.93	37	12.10	11.72	1.97	10.50	74	

TABLE II.—VARIETY SINANDUYONG.

Date	Age	Weight 100 stripped canes	Kilos stripped cane per 100 trash	Kilos juice per 100 kilos strip- ped cane	Correct- ed Brix		Juice (Determined)		Bagasse (Determined)		Cane Calculated		Sucrose extrac- tion by hand-mill			
					%	Purity	%	Inv.	%	Inv.	%	Inv.				
Sept. 7, 1914	6 mo. 1 da.	55.0	45.36	61.36	10.35	6.23	60.19	1.23	4.24	0.22	30	11.70	5.46	0.85	4.52	80
Sept. 21, 1914	6 mo. 15 da.	97.5	59.09	65.49	12.02	7.78	64.72	1.08	6.17	0.44	32	11.00	7.22	0.80	6.00	71
Oct. 15, 1914	7 mo. 9 da.	118.7	65.06	65.26	14.43	9.87	68.39	0.87	7.65	0.38	39	13.50	9.10	0.68	7.90	70
Nov. 2, 1914	7 mo 26 da.	95.0	61.57	61.18	16.19	12.24	75.60	0.73	8.00	0.21	37	14.30	10.60	0.52	10.50	70
Nov. 24, 1914	8 mo. 18 da.	97.5	65.00	56.92	20.35	17.78	87.37	0.25	9.02	0.19	36	15.60	13.96	0.22	16.00	71
Dec. 8, 1914	9 mo. 2 da.	110.0	66.16	64.77	19.25	17.06	88.62	0.30	13.08	0.23	38	13.00	15.50	0.27	16.20	70
Dec. 29, 1914	9 mo. 23 da.	127.5	68.45	60.78	19.32	17.01	88.04	0.28	12.43	0.14	36	14.00	15.22	0.22	16.10	67
Jan. 12, 1915	10 mo. 9 da.	93.1	64.22	55.71	20.13	17.97	89.26	0.46	13.20	0.14	35	15.00	15.82	0.13	17.20	64
Jan: 27, 1915	11 mo. 6 da.	97.5	64.00	51.00	20.75	18.12	87.32	0.53	13.10	0.31	33	16.00	15.77	0.42	17.20	59
Feb. 10, 1915	11 mo. 16 da.	95.0	63.00	51.00	22.20	17.71	84.29	0.69	12.83	0.49	32	16.00	15.20	0.46	16.40	59

TABLE III.—VARIETY LOS BAÑOS WHITE

Date	Age	Weight 100 stripped canes.	Kilos stripped cane per 100 k. trash	Kilos juice per 100 kilos strip- ped cane	Correct- ed Brix		Juice (Determined)		Bagasse (Determined)				Cane (Calculated)				Sucrose extrac- tion by hand-mill.
					%	Purity	%	%	Invert Sugar	Sucrose	Fiber	%	%	Invert Sugar	Sucrose	Fiber	
Nov. 24, 1914	8 mo. 16 da.	85.0	54.83	55.88	16.80	12.94	77.02	0.48	9.58	0.24	25	11.00	11.45	0.37	11.40	63	
Dec. 8, 1914	9 mo.	82.5	55.00	63.63	17.27	15.10	88.07	0.58	10.00	0.18	31	11.20	13.24	0.43	14.40	71	
Dec. 29, 1914	9 mo. 21 da.	90.0	52.94	58.33	17.08	15.05	88.11	0.69	12.49	0.08	30	12.30	13.91	0.43	14.30	61	
Jan. 12, 1915	10 mo. 14 da.	91.2	57.03	62.50	18.83	16.18	85.92	0.50	10.32	0.10	34	11.00	13.90	0.34	15.00	71	
Jan. 27, 1915	10 mo. 29 da.	91.2	56.00	69.91	19.97	16.77	83.98	0.49	13.18	0.12	35	13.30	15.68	0.38	15.40	74	
Feb. 10, 1915	11 mo. 9 da.	90.0	55.00	66.00	20.60	16.12	83.11	0.61	12.62	0.24	33	11.00	14.90	0.48	16.70	73	

From these tables we see that the fiber is small in quantity in the young cane, but increases as the cane matures. The fiber in the cane has an influence on the extraction of juice per hundred parts of cane. It determines the quantity of juice extracted, diminishing the juice as its amount rises. There are two reasons for this. First, the cane with much fiber contains proportionally a smaller amount of juice; and second, the quantity of bagasse is increased and the extraction is made increasingly difficult.

The density and purity of the juice and the amounts of sucrose and crystallizable sugar in the cane change constantly as the cane is ripening. They all increase to a maximum point, whence they begin to drop. The invert sugar in the cane takes a quite different course. When the cane is young, the invert sugar in the cane is present in large amount, but as the cane matures it begins to disappear, part of it doubtless being used in the formation of the fiber. Then, when the cane becomes overripe, the sucrose is inverted and the invert sugar increases again.

The brix reading is an indication of the den-

sity of the juice, and is approximately equal to the percentage of total solids; and purity is the number of parts sucrose in the juice for every 100 parts total solids.

Thus the composition during ripening of the cane fluctuates, but there is a time during this period when the purity is high, the sucrose content is at its maximum, and the total solids, including sugar, is at a minimum, hence a large amount of available sugars. After this period, however, if the cane is still left standing in the field, a retrogression takes place. Deterioration now occurs, the sucrose is inverted into glucose, and consequently the reducing sugar increases, the sucrose decreases, and the purity falls.

In Punjab, India, R. G. Padhye analysed the cane at different dates. He found that "the sucrose percentage was regularly increasing every week till the cane was 12 months old and the glucose and fructose were decreasing. The purity was rising until it reached 92, after which it began to fall. Thus this cane was found to be ripe exactly after 12 months. . . . In the juice of the ripe cane little fructose seems to occur."

TABLE IV.

	Juice (Determined)			Bagasse (Determined)				Cane Calculated			
	%	%	%	%	%	%	%	%	%	%	
	Correct- ed Brix	Sucrose	Purity	Invert Sugar	Sucrose	Invert Sugar	Fiber	Fiber	Sucrose	Invert Sugar	Crystallizable Sugar
ZAMBALES WHITE											
Upper Third.....	12.52	7.22	57.66	1.95	8.50	1.19	28	7.0	6.45	1.81	4.15
Middle Third.....	15.08	11.70	74.26	1.30	10.59	0.41	33	10.0	11.46	1.08	10.00
Lower Third.....	15.45	12.88	83.36	1.29	11.41	0.26	34	10.5	12.42	1.04	11.60
SINANDUYONG											
Upper Third.....	19.59	16.18	82.49	0.99	10.82	0.59	36	13.0	14.61	0.88	14.70
Middle Third.....	22.28	20.74	93.09	0.35	13.39	0.05	41	14.0	18.83	0.27	20.00
Lower Third.....	22.48	21.15	94.08	0.32	13.40	0.03	41	14.0	19.20	0.24	20.60
LOS BAÑOS WHITE											
Upper Third.....	20.40	16.87	82.69	0.91	14.96	0.30	24	8.0	16.30	0.76	15.30
Middle Third.....	22.24	20.34	91.45	0.71	14.39	0.25	34	10.0	18.83	0.60	19.60
Lower Third.....	23.31	21.32	91.46	0.41	12.52	0.22	39	11.1	19.30	0.37	20.40

DISTRIBUTION OF SUGAR IN RIPE CANES.

In order to discover what part of the cane contains the maximum saccharine content, Deerr and Geerligs analyzed the cane, joint by joint, at different period of growth. Deerr (3) found that the internodes contain more sucrose than the nodes, but the nodes contain more fiber than the internodes. Geerligs (5)

found that the maximum sucrose in the joint changes as the cane grows. First it is found in the joint near the bottom, but as the cane begins to ripen it ascends to the middle. If it rains, however, a new growth will start, and there will be less crystallizable sugar at the bottom than at the joint next higher.

For practical purposes we have analyzed

three parts of the cane,—upper, middle, and lower thirds. The division was based on the number of nodes, the average in each third being six. Table IV gives the result of these analysis.

From this table it is seen that every thing except invert sugar is low in the upper third, and becomes higher in the lower third. The reducing sugar is highest in the upper and lowest in the lower third. Brix, purity, sucrose and available sugar are highest in the lower third, and lowest at the upper one. These results agree with those of Deerr's investigation. There is practically no difference between the quantity of fiber in the middle and lower third. The upper third contains less fiber than either of the lower thirds, because in the upper third is to be found the youngest and most rapidly growing part of the cane.

In many sugar plantations, even in cases where the planters themselves own the factory, it is not uncommon to top the cane higher than is reasonable, and still more so when the reputation of the tenants or managers depends on high tonnage. What the results will be one can imagine if he considers that a juice with a high purity when mixed with another having a lower one will inevitably result in lower average purity. It will be noticed that even the top third of the cane contains some crystallizable sugar, in fact the purity of a juice would have to decrease to as little as 40, if it were to be perfectly valueless for sugar making. For this reason the top third of the cane should be included in a harvest to be worked up in a modern mill where several grades of sugar may be produced. In small native mills the value of the product is likely to be dependent on its purity, and for this reason it might pay in such cases to grind the top third of the cane separately. In Java (8), after a certain run, it was noticed that an unusual colored sugar was formed. The cause was traced to the end of the cane, which was not well, removed and contained a tannin-like substances which imparts the color to the sugar. As high topping of cane high is practiced, intentionally or unintentionally in the Philippines, it is not improbable that one of the causes of the exceptionally dark sugars sometimes obtained is the substance mentioned above.

PROFIT AND LOSS AT VARIOUS STAGES OF GROWTH.

We have seen that the cane undergoes a progressive change as it matures, that the

greatest proportion of sugar to total solids or the greatest purity of the juice is very important to our sugar manufacturers, and that this condition is reached when the cane is ripe. The question then is how to determine this point? In some countries the degree of maturity is estimated by the age. The Arabs (7) try to determine it by continuous tastings of the cane. In some places in the Philippines the same method is adapted. In Negros the change of color of the leaves to yellow is taken as an indication of the fitness of the cane for milling. Sometimes arrowing is taken as an indication of ripening.

But these tests or methods of ascertaining the degree of maturity are not dependable. The age of cane is not a reliable indication of its fitness for cutting, because conditions may cause the cane to ripen early or late. Rain during the early part of the plant's life leads to prolonged growth, hence, late maturity. Drought, on the other hand shortens the period required for maturity. The tasting method is of course a crude and unsatisfactory one. As to the yellowing of the leaves as an indication of maturity, there seems to be no way in which to correlate it with high sucrose content in the cane.

Arrowing is a misleading sign, for, when the arrows shoot out and seeds are formed, the sucrose deposited in the joints is inverted and transferred to the flower and seeds, and after the arrows fall there will be less sucrose in the cane than there was before the arrow developed. In fact many farmers avoid planting the varieties of cane that arrow. Nor can any other ocular examination be depended upon for determining when cane should be cut. The best method known is chemical analysis, for behind it are figures that tell the exact sugar content of the cane. In the Philippines the canes mature between 9 and 11 months, and the analysis then should begin at the 9th month and should be continued until it shows that the sucrose and purity are at a maximum. Should this test be carried out on the farm there is no possible doubt that a higher grade of sugar than that in the markets of Iloilo or Manila could be obtained. With such a low margin of profit as exists in our industry to-day, every possible care should be taken to improve the final financial result.

Walker (6), investigating the sugar industry in Negros six years ago, found the grade of sugar corresponding to different purities of the juice. Some of his data follow:

Brix	Sucrose	Purity	Polariza- tion of sugar	Grade
20.86	16.18	77.57	68.6	No. 4
20.30	17.77	87.04	86.0	" 2
20.35	18.03	88.61	87.9	" 1
20.98	18.35	87.48	80.0	" 3
19.40	17.10	88.20	86.4	" 2

It was his experience in the many tests he made that some of the juices with high purity produced low grade sugar. This was due to lack of judgment on the part of the boiler, who sometimes improperly clarified the juice or overcooked the sugar. Under ideal conditions of sugar making the purity of the final sugar would be much higher than the apparent purity of the juice, because of the removal of salts, reducing sugars, etc. in the molasses. But, under ordinary conditions, boiling sugar in an open kettle, without removing the molasses, the percentage of marketable sugar happens to be about the same as the quotient of purity of the juice. Assuming now that this is true, let us find out the possible results if the variety Los Baños White be milled at different ages.

Walker (6), in his chemical control of the native mill in San Carlos, Negros, worked with a cane having 10.52% fiber, and found that the extraction of sucrose in juice on sucrose in the cane was 75.00%. As the Los Baños White variety is nearly the same in fiber content, the same efficiency of milling will be used in the present computation.

Age	Purity	Available sugar	Assumed polariza- tion	Grade of Sugar
8 mo. 16 das.	77.02	11.40	77.02	No. 4
9 " 21 "	88.11	14.30	88.11	" 1
11 " 9 "	83.11	16.70	83.11	" 3

The yield per hectare at these different ages was calculated from the number of canes per hectare as estimated by Mr. Adriano and the average weight of 100 canes at each age as shown in Table III. (Los Baños White).

Assuming the percentage of crystallizable sugar shown in Table III and 75% extraction the yield of sugar per hectare and its value computed on the current market prices are tabulated below:

Age	Calculated yield of cane per Ha.	Piculs sugar	Price per Picul	Total Value
8 mo. 16 das.	34.9	46.8	P-5.00	P-234.00
9 " 21 "	37.0	62.5	7.00	437.85
11 " 9 "	37.0	73.1	6.00	438.90

These figures may be compared with those for a modern mill assuming the same weight of cane and the same percentages of crystallizable sugar as before, but assuming an extraction of 95%, and the market price of 97° sugar, which is 20 centavos a kilo or P12.64 per picul.

Age	Calculated yield of cane per Ha.	Piculs Sugar	Total Value
8 mo. 16 das.	34.90	58.1	P-735.00
9 " 21 "	37.00	79.0	998.56
11 " 9 "	37.00	92.6	1170.46

COMPARATIVE MERITS OF LOCAL VARIETIES.

The origin and characteristics of the local varieties have been published elsewhere (2). Therefore, it is only necessary for us here to give their chemical merits.

The variety Zambales White is a juicy cane, but its juice has a low purity. The percentage of available sugar is small and reducing sugar plentiful. The quantity of fiber is small. The yield of sugar per hectare by a modern mill of 95% extraction would be 4.8 tons, but because of the low purity of the juice the sugar will probably polarize about 88°. This defect would render this variety unfit for milling purposes. In many localities it is grown only for eating.

The Sinanduyong variety contains a high percentage of sugar, and the brix and purity are higher than either of the two other varieties. The fiber in the cane reaches as high as 16%. The yield of sugar per hectare would be 3.9 tons of 96° sugar.

The Los Baños White variety is a heavy yielder. Neither sucrose nor brix stands as high as that of the Sinanduyong variety, but the purity runs very close. It has slightly less fiber and solids than sugar. Therefore it is softer and easier to crush in the mill. The yield per hectare would be 5.86 tons of 96° sugar.

Of the three varieties the Zambales White matures earliest, the Los Baños follows, and the Sinanduyong is the latest. Sinanduyong contains the most sucrose, and Los Baños White, is next. The latter, having less fiber and solids than sugar and giving greater yield, is the more preferable for milling pur-

pose. As regards saccharine content in general, these two varieties can compare favorably with the best varieties in Negros or in any other countries.

GENERAL CONCLUSIONS.

1—During the ripening period of the cane a point is reached when the purity is very high, the sucrose content is at its maximum, and the reducing sugar at its minimum.

2—After this point is reached and maintained for a length of time depending on the variety of cane and the soil and climatic conditions, the purity and sucrose content of the cane decrease and the reducing sugar increases.

3—During the time of highest purity, maximum sucrose content, and minimum reducing sugar, the sugar made from the juice is of high grade.

4—When cane is milled at the proper time, more sugar is obtained, and greater profit is realized.

5—Chemical analysis is the only known means of determining the exact point of maturity.

6—The upper third of the cane contains least sucrose and most reducing sugar, and has a low purity. The two lower thirds contain the maximum sucrose, the minimum invert sugar and have the highest purity; hence if the juice of the lower two thirds be mixed with that of the upper third, the resulting mixture will have lower purity than either of the lower thirds taken alone.

7—Topping the cane too high leads to the production of low grade sugar.

8—The sugar produced from a hectare of Los Baños White by a modern mill is worth

more than twice that from the same area by native processes. Moreover, if the cane is harvested before it is matured, the loss by primitive method is especially great, because of the fact that a low-grade sugar is produced.

From these facts it is therefore recommended that the cane be cut and milled when it has just reached the point of actual maturity. This point should be ascertained by chemical analysis. Lastly, the topping of the cane should be reasonably low if a high grade sugar is to be produced by the native process, or else the top third of the cane should be ground separately.

Acknowledgment is due to Professor Deming for his suggestion of the plan and for his criticism of this work and to Professor Baker for his review of the manuscript.

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CHEMICAL CHANGES IN THE RIPENING COCONUT

BY TOMAS VISTA Y ISLES.

Thesis presented for graduation from the College of Agriculture No. 35.

INTRODUCTION.

The changes occurring in the ripening coconut have been studied by Gonzales (1). However, the value of his work is somewhat diminished because he did not know the exact ages of the nuts he analyzed, but was compelled to use size, color, and thickness of the meat to indicate the relative ages of the nuts, an assumption which is subject to many errors. For this reason it seemed well to continue his work, especially since the number of nuts he examined was rather small. In the present work the ages of the nuts analyzed are expressed in days, counting from the day each spathe or flower-cluster opened.

The procedures used in all determinations were official methods, (2) unless otherwise stated.

The percentages of husk, shell, and milk, in terms of the whole nut, were taken from their actual weights, while the percentage of meat (to avoid loss by evaporation) is assumed to be the percentage calculated on the difference between the weight of the whole nut and the sum of the weights of husk, shell, and, milk.

CHANGES IN COLOR, SIZE, AND WEIGHT.

When the spathe opens a cluster of pistillate and staminate flowers having a yellowish color is exposed to the sun. About the third or fifth week the female flowers become fertilized. It is interesting to note that self-pollination is hardly possible, because before the stigmas become

receptive all staminate flowers have been shed. After the pistillate flowers are pollinated the fertilized ovaries begin to increase in size. From this time on we can divide the changes taking place during the ripening of the coconut into four groups, namely:

- 1st. changes in color.
- 2nd. changes in size.
- 3rd. changes in weight.
- 4th. changes in chemical composition.

The yellowish color of the embryonic fruits, on exposure to the sun, is gradually changed to green, and finally to brown, when the nuts have become nearly ripe.

In the case of the yellow and red varieties the change in color is from yellowish to yellow and red respectively, until such time as the color in both varieties is changed to brown. As the color changes are well marked, they are a fairly efficient guide in determining the degree of ripeness of the nuts.

The young nut at first increases most rapidly in size longitudinally (measured from the base to the tip of the fruit) until the meat begins to form, and afterwards transversely.

On this account the ratio of the longitudinal diameter to the transverse diameter tends to decrease as the nut grows older, though it does not always happen that the oldest nuts have a greater longitudinal than transverse diameter. These variations in form continue until the nut is ripe. They are most striking when the measurements of the shell are taken, as the variation in shape of the husk is not so noticeable. Table I shows the size of nuts of different ages, arranged in order of increasing age.

(1). Phil. Agriculturist and Forester, Vol. III, 2, 1914.

(2). Official and Provisional Methods of Analyses, U. S. Dept. of Agr., Bur. of Chem., Bull. 107. (Revised).

TABLE I.
VARIATIONS IN COLOR AND SIZE.

No. of Nuts	Date Spathe Opened	Date of Analysis	Age in Days	Color	Diam. of Husk.		Diam. of Shell	
					Long. cm.	Trans. cm.	Long. cm.	Trans. cm.
1	Oct. 8, '14	Jan. 23, '15	107	Green	14.5	11.0	9.2	7.2
2	Sept. 26, '14	„ 30, '15	126	„	12.0	8.5	7.5	4.5
3	Aug. 29, '14	„ 9, '15	133	„	16.0	13.5	11.0	8.8
4	„ 15, '14	„ 9, '15	147	„	15.4	15.8	11.9	11.2
5	July 21, '14	Dec. 23, '14	149	„	16.0	14.2	10.5	9.5
6	June 29, '14	„ 12, '14	166	„	17.0	16.0	10.7	10.4
7	May 29, '14	Nov. 28, '14	173	„	15.0	17.0	11.0	13.0
8	Mar. 6, '14	Sept. 28, '14	206	„	19.5	19.5	11.5	14.5
9	July 12, '14	Jan. 30, '15	202	„	15.0	15.2	8.8	10.5
10	May 19, '14	Dec. 12, '14	207	„	20.0	20.0	13.0	14.0
11	May 1, '14	Nov. 28, '14	211	„	16.0	16.5	11.4	13.3
12	Apr. 6, '14	„ 21, '14	229	„	17.5	17.0	11.5	13.0
13	Feb. 10, '14	Sept. 28, '14	220	„	19.5	20.0	12.5	14.0
14	Oct. 12, '13	Jun. 21, '14	252	„	18.5	15.0	12.0	12.0
15	Feb. 12, '14	Nov. 21, '14	282	„	19.0	17.0	10.8	12.5
16	Dec. 11, '13	Sept. 26, '14	289	„	19.0	19.0	12.0	11.0
17	Nov. 13, '13	„ 12, '14	303	„	18.5	15.0	10.5	11.0
18	Feb. 12, '14	Dec. 23, '14	324	„	17.5	17.5	17.0	13.0
19	Dec. 4, '13	Nov. 14, '14	345	„	18.8	15.0	10.2	11.0
20	Oct. 5, '13	Sept. 26, '14	356	Turning Brown	20.0	13.5	11.5	9.0
21	Sept. 7, '13	Sept. 4, '14	362	„	16.0	12.0	9.5	8.0
22	„ 28, '13	„ 12, '14	349	Green	17.0	11.5	9.0	7.0
23	July 16, '13	July 30, '14	370	Brown	20.0	17.0	12.0	12.0
24	„ 13, '13	„ 24, '14	371	„	18.5	15.5	12.5	11.5
25	Nov. 6, '13	Nov. 14, '14	373	Turning Brown	19.0	18.5	10.0	9.5
26	Aug. 15, '13	Sept. 26, '14	407	„	16.25	13.5	9.5	8.5
27	Dec. 14, '13	Jan. 9, '15	391	Brown	19.0	13.4	10.3	11.0
28	July 17, '13	Aug. 29, '14	408	„	20.0	17.5	12.3	17.7
29	„ 15, '13	„ 29, '14	410	„	17.3	17.5	11.3	13.0
*30	„ 19, '13	Oct. 14, '14	462	„	17.0	16.0	10.8	10.0
*31	„ 12, '13	„ 22, '14	477	„	16.0	15.8	10.0	12.0

Parallel with the increase in size is the increase in weight. The nuts gain both moisture and dry matter at first, but during the later stages of ripening the loss due to evaporation of water more than counterbalances the gain due to increase of dry matter, and the nuts actually lose in weight. Because this loss of moisture takes place very largely from the husk, there is even a shrinkage of the latter, so that measure-

ments of the external diameter of nuts in the husk show that a decrease of size accompanies the decrease of weight during the final stage of ripening.

In the case of mature nuts, though they contain the maximum amount of dry matter in the form of meat, shell, and husk, they are far lighter than those somewhat younger, because a large part of the water content of the husks has evaporated. Table II shows the changes in weight of nuts at different ages.

* Sprouted Nuts.

TABLE II.

VARIATION IN RELATIVE WEIGHTS OF HUSK, SHELL, MEAT, MILK AND SPECIFIC GRAVITY.

No. of Nut	Age in Days	Total Weight of Nut Grams	Weight of Shell Grams	Weight of Husk Grams	Weight of Water Grams	Weight of Meat Grams	Percent of Shell	Percent of Husk	Percent of Water
1	115	946	52	710	183	0	5.56	47.04	20.40
2	126	423	30	272.7	120	0	7.09	64.47	28.42
3	134	1623	106	1125.5	391	0	6.54	69.34	21.12
4	146	1923	152.7	1109.0	661	0	7.94	57.66	36.40
5	149	1678	118	1116.0	443.5	0	7.03	66.50	26.47
6	166	2098	138.0	1364.0	696.0	0	6.57	65.01	28.42
7	179	2104	209.8	1092.0	952.1	39.2	9.97	51.90	35.07
8	201	3345	292.5	2022.5	750.3	279.7	8.92	60.47	21.09
9	201	1579	142.2	1052.0	287.0	97.8	9.00	65.29	18.27
10	207	3780	310.3	2445.0	787.0	237.7	8.26	64.15	20.07
11	211	2149	197.5	1190.0	587.0	174.5	9.18	56.28	26.44
12	228	2437	223.7	1333.5	641.3	238.5	9.06	54.71	26.32
13	229	3598	269.4	2308.2	813.3	217.1	7.12	60.13	21.88
14	250	1290	160.0	298.0	522.0	310.0	12.40	27.87	39.43
15	281	1732	105.0	829.0	397.0	401.3	95.54	47.86	26.44
16	289	2535	206.3	1533.0	552.7	243.5	8.13	60.69	17.45
17	312	1674	173.0	976.0	299.1	225.9	10.83	58.36	16.29
18	323	2061	234.0	1001.0	516.0	310.0	11.35	48.56	25.47
19	334	1104	154.4	445.2	208.3	296.1	19.17	40.31	19.23
20	355	697	92.3	261.4	132.5	211.3	13.25	38.87	18.99
21	361	737	90.1	434.9	73.0	149.0	12.25	57.53	9.93
22	369	831	86.1	546.7	70.0	128.2	10.36	68.19	8.42
23	370	1120	153.0	310.0	239.8	401.0	13.66	27.67	26.87
24	371	1160	164.0	287.0	277.0	332.0	14.14	24.74	32.50
25	372	924	123.3	477.5	110.5	212.7	13.34	41.55	11.95
26	385	721	102.1	230.5	95.0	293.4	14.27	31.95	13.06
27	400	844	133.5	218.0	197.0	295.5	15.81	25.82	23.69
28	401	1477	195.4	421.0	363.0	497.6	14.52	28.53	22.54
29	408	1345	193.0	334.6	356.0	461.2	13.07	24.87	26.48
*30	453	666	128.6	240.0	101.5	184.5	19.69	37.32	15.28
*31	465	866	167.6	203.5	120.5	351.9	19.35	23.39	12.47

It appears that the percentage of shell increases up to the very last, though the actual weights of shells from nuts of different ages do not show any such tendency, the increased percentage being due to the decrease of the total weight of the nut during the later stages of ripening. The percentage of husk decreases rapidly from the very first and if actual weights are considered it will be found that the weight of husks of fully mature nuts is from one fifth to one tenth of that of those that are about half mature. The percentage of water existing as liquid inside the nut is subject to great variations in individual nuts, but there is a decided tendency for the actual weight of water to decrease during

the later stages of ripening. The total percentage of meat increases up to the very last, though this apparent gain during the last 100 days is due as much to the decrease of the total weight of the nut as to any other cause. The great variation in the weight of the endosperm of fully mature nuts is not altogether due to their differences in size, but rather to the fact that the meat of some nuts is decidedly thicker than that of others. This fact should be taken into consideration in the selection of seed-nuts by copra growers.

Another way which may be used in determining the degree of maturity of fruits, besides changes in color and size, is by means of specific gravity. Young nuts are not only often far heavier than the old

* Sprouted Nuts.

ones, but have higher specific gravities than the latter.

CHEMICAL CHANGES IN THE MILK.

The milk or liquid portion of unripe nuts is turbid, containing in semi-solution substances which can easily be precipitated by lead sub-acetate. The milk of the ripe nuts is also turbid, and when germination takes place oil may be seen floating in it.

The milk of coconuts, young or old, has an acid reaction. This is partly due to carbon dioxide dissolved in it, but remainly to

organic acids, as may be shown by the fact that the juice when titrated with a standard alkali gives almost as great a figure, using methyl orange as an indicator, as it does with phenolphthalein. The acidity increases as the nut matures, and is greatest during the formation of the meat, then decreases, though there is toward maturity an irregular fluctuation. The amount of amino acids decreases, while the nitrogen content of the milk increases as the nut matures. Table III shows these changes in the milk at different ages.

TABLE III.
CHANGES IN THE MILK.

No. of Nuts	Age in Days	Acidity in 100 c. c. expressed as n/10 Acid	No. c. c. of 6646 n/10 Alk. used in 100 c. c. Titrating Am. Acid	Grams Amino Acids 100 c.c. expressed as glycocoll	Specific Gravity of Milk	Percent of Nitrogen	Thick-ness of Meat cm.
1	107	9.90 c. c.	1.19 c. c.	.0059	1.0102	.0095	0
2	126	3.95 c. c.	1.50 c. c.	.0075	1.0220		0
3	133	14.11 c. c.	4.91 c. c.	.0245	1.0125	.0016	0
4	147	14.08 c. c.	10.30 c. c.	.0514	1.0200	.0024	0
5	149	14.00 c. c.	3.67 c. c.	.0183	1.0125	.0025	0
6	166	14.24 c. c.	12.39 c. c.	.0618	1.0135	.0030	0
7	173	12.60 c. c.	13.38 c. c.	.0668	1.0195	.0028	0.10
8	206	18.76 c. c.	9.38 c. c.	.0468	1.0200	.0023	0.30
9	202	12.72 c. c.	3.50 c. c.	.0175	1.0230	-----	0.40
10	207	16.06 c. c.	13.66 c. c.	.0681	1.0150	.0038	0.55
11	211	11.95 c. c.	9.58 c. c.	.0478	1.0235	.0021	0.45
12	229	13.00 c. c.	11.82 c. c.	.0590	1.0250	.0049	0.50
13	220	9.56 c. c.	7.92 c. c.	.0395	1.0220	.0037	0.50
14	252	-----	-----	-----	1.0020	.0027	0.90
15	282	11.40 c. c.	13.98 c. c.	.0696	1.0260	.0045	1.10
16	289	9.16 c. c.	8.00 c. c.	.0399	1.0235	.0052	1.10
17	303	12.00 c. c.	9.60 c. c.	.0479	1.0200	.0038	1.00
18	324	17.60 c. c.	6.80 c. c.	.0343	1.0210	.0025	0.70
19	345	13.16 c. c.	6.14 c. c.	.0306	1.0200	.0020	1.00
20	356	8.00 c. c.	6.80 c. c.	.0343	1.0165	.0030	0.90
21	362	12.88 c. c.	12.44 c. c.	.0521	1.0150	.0017	1.00
22	349	7.60 c. c.	6.44 c. c.	.0321	1.0200	.0012	1.00
23	370	11.28 c. c.	8.00 c. c.	.0399	1.0280	.0023	1.10
24	371	9.46 c. c.	4.73 c. c.	-----	1.0100	.0091	1.00
25	373	12.80 c. c.	9.02 c. c.	.0449	1.0190	.0042	1.30
26	407	8.08 c. c.	17.20 c. c.	.0848	1.0140	.0015	1.20
27	391	7.28 c. c.	4.08 c. c.	.0243	1.0160	-----	1.00
28	408	8.00 c. c.	12.20 c. c.	.0128	1.0165	.0095	1.20
29	410	5.24 c. c.	20.96 c. c.	.0105	1.0140	.0037	1.20
30	462	8.80 c. c.	13.56 c. c.	.0168	1.0200	.0021	1.30
31	477	7.40 c. c.	12.44 c. c.	.0128	1.0210	.0110	1.20

The procedure used in determining amino acids in the milk is to treat 100 cc. of the milk with 10 cc. of neutral formaldehyde. The acid set free (1), is titrated with standard alkali free from carbon dioxide, using phenolphthalein as an indicator. From the number of cc. of standard alkali used in titration, the number of grams of amino acid, expressed as glycocoll, is calculated.

The milk of the young nut has lower specific gravity than that in which meat is being formed, and towards maturity irregular fluctuations occur, in which there is a general tendency to decrease. The specific gravity of the milk of nuts which have already sprouted, as nuts No. 30 and 31, is higher than that of the milk of mature ones that have not sprouted.

The percentage of milk gradually rises until the meat is formed, then decreases with further development of the latter,

(1). Biochem. Ztschr. (1907) 48,40; also Ztschr. physiol. Chem., 60 (1909); 64 (1910) 121.

though irregular fluctuations occur here also.

Sucrose is absent in the milk of young nuts; the percentage of invert sugar increases until the formation of meat begins. At this time sucrose is being formed, which increases with further development of the meat, but the percentage of invert sugar is always greater than that of sucrose.

In the case of the milk of sprouted nuts the percentage of sucrose increases, possibly, at the expense of the oil in the endosperm, which decreases at same time. In Table IV the changes in specific gravity, percentages of milk, invert sugar, and sucrose are well illustrated.

TABLE IV.
VARIATIONS IN SPECIFIC GRAVITY, PERCENTAGES OF INVERT SUGAR
AND SUCROSE IN MILK.

No. of Nut	Age in Days	Thickness of Meat cm.	Percent of Milk	Specific Gravity of Milk	Percent of Sucrose	Percent of Invert Sugar.
1	107	0	20.40	1.0102	0	1.2167
2	126	0	28.42	1.0220	0	1.7827
3	133	0	21.12	1.0125	0	1.4903
4	147	0	36.40	1.0200	0	2.1626
5	149	0	26.47	1.0125	0	1.6200
6	166	0	28.42	1.0135	0	2.3944
7	173	0.10	35.07	1.0195	0	2.8585
8	206	0.30	21.09	1.0200	.4833	2.0871
9	202	0.40	18.27	1.0230	.6460	2.7728
10	207	0.55	20.07	1.0150	.2284	1.6549
11	211	0.45	26.44	1.0235	.1307	2.8599
12	229	0.50	26.32	1.0250	.2273	2.5565
13	220	0.50	21.88	1.0220	.9031	2.0786
14	252	0.90	39.43	1.0020	.5030	1.0470
15	282	0.10	26.44	1.0260	.6965	1.7926
16	289	1.10	17.45	1.0235	.4167	1.7564
17	303	1.00	16.29	1.0260	.5938	1.1133
18	324	0.70	25.47	1.0210	.4226	2.1929
19	345	1.00	19.23	1.0200	.2129	1.5611
20	356	0.90	18.99	1.0165	.9624	2.0238
21	362	1.00	9.93	1.0160	.5121	2.1241
22	349	1.00	8.42	1.0200	.4998	2.7968
23	370	1.10	26.87	1.0280	.5989	1.8040
24	371	1.00	32.50	1.0100	.6490	1.4930
25	373	1.30	11.95	1.0190	.2876	1.1510
26	407	1.20	13.06	1.0140	.5328	1.3316
27	391	1.00	23.69	1.0160	-----	-----
28	408	1.20	22.54	1.0165	.2936	1.2130
29	410	1.20	26.48	1.0140	.3815	1.3282
30	452	1.30	15.28	1.0200	2.2365	2.7502
31	467	1.20	12.47	1.0210	1.7821	1.2617

CHEMICAL CHANGES IN THE MEAT OR SOLID ENDOSPERM.

The very young nut contains no meat. When meat is formed it first appears as a thin coating of white watery substance. At first it does not occupy the whole inner surface of the shell, but only one end, that which is opposite the eye. As the meat gradually increases in thickness during further development it occupies more and more space until the whole inner surface of the shell is covered with it. Concurrent with this is the gradual hardening of the meat, beginning from the thickest part, and proceeding towards the thin part, which is near the eye.

Since the thickness of the meat at the two ends is not the same, even in mature nuts, measurements of the thickness of meat were taken at points between these two extremes.

The newly formed meat contains no sucrose, but only invert sugar; the latter is gradually produced, in increasing amounts, in the further development of the meat, and as the nut ripens the amount of invert sugar decreases. Mature or ripe nuts have therefore nearly equal amounts of sucrose and invert sugar. But when sprouting begins the percentage of both sugars is increased, as suggested by nuts number 30 and 31 in Table V.

TABLE V.
CHANGES IN THE MEAT.

No. of Nut.	Age in Days	Thickness of meat cm.	Character of Meat	Total Wt. of meat g.	% of Moisture	% of Inn. Sugar	% of Sucrose	% of N-wet basis	Total Wt. of protein	% Oil Wet basis	% Oil Dry basis	Total Wt. Oil	% Ash Wet basis	% Ash Dry basis	Total Wt. ash
7	173	0.10	watery	39.2	91.82	.34	0.0	0.485	1.188	0.73	9.00	0.289	---	---	---
8	206	0.30	"	279.7	91.72	.54	0.99	0.139	2.394	1.32	14.71	0.395	0.006	0.070	0.001
9	202	0.40	soft	97.8	91.76	.45	0.56	---	---	2.22	26.92	2.171	0.006	0.071	0.005
10	207	0.55	"	237.7	92.10	.55	0.71	0.438	6.507	2.77	35.09	6.564	0.01	0.12	0.023
11	211	0.45	"	174.5	92.01	.50	---	0.417	4.547	3.38	39.77	5.898	0.02	0.16	0.034
12	229	0.50	"	238.5	87.05	.26	0.68	0.277	4.129	6.58	50.95	15.477	0.02	0.16	0.047
13	220	0.50	"	217.1	88.25	.65	1.43	0.207	1.389	6.05	50.57	13.134	0.06	0.45	0.130
14	252	0.90	hard	310.0	79.62	.24	0.29	0.420	8.137	10.89	48.52	33.759	0.08	0.40	0.248
15	282	1.10	"	401.0	75.43	.24	0.60	0.498	12.490	10.80	50.73	43.311	0.08	0.37	0.320
16	289	1.10	"	243.5	73.16	.43	0.69	0.440	6.696	10.69	39.84	26.30	0.20	0.73	0.487
17	303	1.00	"	225.9	69.85	.25	0.45	0.560	7.906	12.37	50.99	29.944	0.23	0.75	0.519
18	324	0.70	soft	310.0	63.45	.14	0.35	---	---	18.48	50.28	57.288	0.28	0.76	0.868
19	345	1.00	hard	296.1	60.09	.96	1.19	0.346	6.756	22.53	56.44	66.711	0.27	0.68	9.799
20	356	0.90	"	211.3	60.65	.39	0.76	0.213	2.812	---	---	---	---	---	---
21	362	1.00	"	149.0	56.36	.19	0.38	0.382	3.582	24.05	55.09	35.835	0.37	0.84	0.551
22	349	1.00	"	228.2	53.31	.22	0.45	0.212	1.698	25.37	61.36	32.524	0.23	0.56	0.284
23	370	1.10	"	401.0	68.01	.47	1.11	1.028	25.665	17.86	55.81	71.619	0.29	0.92	1.162
24	371	1.00	"	332.0	60.37	.19	0.25	1.065	22.057	20.89	52.70	69.355	0.37	0.94	1.228
25	373	1.30	"	212.7	58.50	.72	1.68	0.058	14.064	21.22	51.14	45.135	0.40	0.96	0.580
26	407	1.20	"	293.4	44.65	.12	0.17	0.384	25.502	32.82	59.29	94.364	0.53	0.96	1.554
27	391	1.00	"	295.5	53.01	---	---	---	---	33.02	70.25	97.574	0.46	0.99	1.359
28	408	1.20	"	497.6	38.53	.14	0.20	0.646	51.190	25.28	49.50	125.833	0.42	0.89	2.089
29	410	1.20	"	461.2	45.69	.19	0.35	0.864	19.154	28.31	52.13	130.566	0.46	0.84	2.121
30	452	1.30	"	184.5	43.29	.98	1.00	0.145	2.993	34.13	60.19	69.944	0.44	0.98	1.808
31	467	1.20	"	351.9	40.07	1.30	1.23	0.190	4.188	31.20	53.79	109.793	0.31	0.71	1.097

In the case of pineapples large amounts of sugars (1) are accumulated during the ripening of the fruit, while with dates an accumulation of sugar (2) takes place shortly before ripening.

As the nuts ripen the meat loses water. The percentage of dry matter in the meat is increased until the endosperm is well developed.

At the beginning of the formation of meat oil is absent, but as the nut ripens it appears and continues to accumulate. Parallel with this is an increase in the ash content of the meat.

The oil content of sprouted nut decreases. It is perhaps changed into sugars, for the meat of sprouted nuts contains much sugar. The ash content of the endosperm also decreases as the seedling becomes older.

SUMMARY:

The conclusions drawn by Gonzales (3) were:

"During the first period there is an accumulation of invert sugar and amino acids in the milk or watery portion. The meat is still absent, the shell and husk are soft and watery, and the nut as a whole has its greatest diameter along the main axis.

During the second period of growth sucrose appears in the milk and the specific gravity of the latter is high. During all this time water is lost from the coconut, though its total weight continues to increase. The nut has in the meantime been changing its shape, and begins to acquire its greatest diameter in a direction at right angles to the main axis.

During the closing period of ripening there is a sudden rise in the content of oil in the endosperm. The specific gravity of the milk falls at the same time owing to the transfer of nutrient materials or to respiration. In the meantime the shell has become impervious, and the drying out of the husk results in a loss of weight, which overbalances the gain in weight due to other changes".

The present work has confirmed the above statements, except that it appears that

mature nuts do not always have their greatest diameter in a direction at right angles to the main axis.

In addition to the conclusions cited above the following are deduced from the preceding data:

1. The meat begins to form when the nut is about six months old.

2. Only invert sugar is present in the meat when it is 0.1 cm. thick.

3. The general tendency of the nitrogen content of the meat is to rise.

4. As the nut becomes older the evaporation of the water from the husk causes an apparent increase in the percentages of meat, shell, and water; but if the actual weights are considered it will be found that the weight of the shell undergoes little change during the later stages of ripening, while the weight of water appears to be subject to irregular fluctuations tending towards a decrease. The actual weight of the meat does not appear to increase much if any during the last 100 days though analysis during this time show that the endosperm changes greatly in composition. Most of the oil in fact is produced after the period when the nuts have become very decidedly brown.

5. When the nuts germinate the percentages of sucrose and invert sugar contained in the milk increase very rapidly. The percentages of these two sugars in the meat increase likewise. The nut that has just begun to sprout appears to make use of the nitrogenous constituent of the endosperm before much of the oil is removed, though the fact that but two nuts were analyzed will leave this statement somewhat in doubt.

6. In this locality it appears that nuts require in the neighborhood of 370-410 days to become fully ripe, counting from the moment the spathes open.

The writer wishes to express his thanks to Prof. Deming for suggestions and help during the progress of this work, and to Dean Copeland for valuable information.

Correction.—The age of the nuts, shown in Table II, should be corrected to agree with Table V. Table II should show specific gravities of the nuts, varying from an average of 1.048 for the six youngest nuts to one of 0.970 for the six oldest ones.

(1) Kelley; Hawaii Expt. Sta., Bull. 28, 16-17.

(2) Vinson; Arizona Expt. Sta., Bull. 66, 405.

(3) Phil. Agriculturist and Forester, Vol. III, 2 (1914) 31.



PANORAMIC VIEW, COLLEGE OF AGRICULTURE, MT. MAKILING IN THE BACKGROUND.

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EDITORIAL.

THE INAUGURATION OF PRESIDENT VILLAMOR

Introduced by Resident Commissioner Manuel L. Quezon and inducted into office by Vice-Governor General Martin, who is ex-officio Chairman of the Board of Regents of the University of the Philippines, Hon. Ignacio Villamor was inaugurated on August 12, 1915, as second president of the University of the Philippines.

The celebration was held in the Auditorium of the Philippine Normal School. Among the other high government officials present, there were Governor General Harrison, Speaker Osmeña, and Commissioner Palma. The Student Body of the University formed the greater part of the audience. The students of the College of Agriculture hired for the occasion a special boat which conveyed them from Los Baños to Manila.

We quote the following from the address of President Villamor, entitled "The University and the People":

"On an occasion similar to this, my predecessor, Dr. Murray Bartlett, said:

'For us there is but one subject clear and well-defined in the hearts and minds of us all, and this is the subject "A University for the Filipinos." This bare campus speaks of hope rather than achievement, of promise rather than of fulfilment. It is not a time for theorem or dogma, for research or deduction; it is a time for vision.'

"Hardly five years have elapsed since those words were uttered, and yet this campus, which was bare then and spoke only of hope and of promise, now offers to our contemplation a great edifice, the majestic pillars of which bespeak the support of a flourishing and vigorous civilization. But we are still in a period of organization; and at this initial stage there is nothing more important than to consider the plan as a

whole, together with the details of its performance, taking into account the objects of this institution as conceived by its founders as well as the needs of these Islands, for this will give us encouragement in our efforts to advance the work begun with enormous sacrifice and yet with great enthusiasm on the part of the people.

"The purposes which the Legislature had in mind in founding this University were eloquently expressed by the committee of the Assembly which reported upon the Shuster Bill. This committee said:

'It does not require great effort to understand the supreme importance of the establishment of a Government university, and the immeasurable benefits which the student class and the country as a whole will derive from it. The progress of a nation not only depends on the development of its

material resources, but depends as well on the promotion of its intellectual faculties in the arts and sciences. Europe stands pre-eminent in learning, due to its schools, colleges, academies, and universities; and the United States with over 600 higher educational institutions, and with its enormous wealth, is now the envy of the world. The Government of the Philippine Islands can not but fulfil its high mission, which may be summarized as the raising of the intellectual level of the Filipino people.'

"Thus it is seen that the intention of the Assembly was to establish a great institution which should crown the public school system and at the same time embody the sentiments, needs, and aspirations of the people—a center of education where Philippine culture, inspired by the Spanish civilization and strengthened by the vigorous spirit of the great American Nation, should flourish.

"Placed at the head of this national enterprise, to take part in the performance of the work, I feel called upon on this occasion to treat of a subject which may serve to sketch the work which we propose to carry out. And inasmuch as this institution is maintained by public funds, what more interesting subject can I select than the relations between the University and the people? This is the topic to which I wish to invite your attention.

"According to President Hadley of Yale University, (1) a university means a group of colleges or schools which prepare for many distinct vocations—a place of universal study, as contrasted with one that pursues a single branch of learning. Some think of it as an institution which is widely known for its discoveries and for its teachers of science and literature, a school of universal reputation, as distinguished from one of merely local fame. In the minds of others, it is a place where students can acquire a wide range of knowledge, where they can fit themselves for their duties as citizens of a self-governing community.

The University of the Philippines, in its present organization, is composed of the Colleges of Medicine and Surgery, Law, Engineering, Agriculture, Veterinary Science, Liberal Arts, and the School of Fine Arts.

"A line of demarcation has been drawn

between a college and a university by virtue of which the former is specially to mold character, and the latter to enrich knowledge and give training for the technical professions. But it seems to be clear that this line of distinction is purely accidental, for a college that primarily aims to develop character also aims to extend the field of human knowledge and to give professional education; while a university that primarily aims to increase knowledge and to extend the field of science may have for its secondary purpose the enhancement and enrichment of character.

"For us the University of the Philippines, designed as it is to meet the needs of this country, should aim, first, to extend the field of scientific knowledge; and, secondly, to mold character. *Her ideal should be efficiency founded upon science and inspired by character.*

"The Philippine Legislature itself points out to us that the purpose of this University is to provide advanced instruction in literature, philosophy, the sciences, and the arts, and to give professional and technical training.

Starting, then, from this point and without losing sight of the needs of the inhabitants of the Philippines, the first of which is the preservation of life, the University has been devoting all the attention necessary to the organization of the College of Medicine and Surgery. This college has attained so great success that the board of regents of the University of New York classifies it among the best of medical colleges. The fact just mentioned is a good portent not only for the people at large, but more especially for these who realize that in these Islands there is only 1 doctor for every 200,000 inhabitants. It shows that the University aims not only produce the greatest possible number of physicians who, with their scientific knowledge, will aid nature to repel those forces inimical to our well-being, but that it also purposes to train doctors who, with the searching light of science, will discover and eradicate the social evils with which mankind is afflicted—the diseases that diminish the probabilities of living and constitute a great obstacle to the increase of population.

"Next in importance to the preservation of life follows the preservation of rights, to the teaching of which the University must also turn its attention in view of the grow-

(1) Report of the President, 1913-14.

ing demand on the part of our youth for this study. Such a great enthusiasm for the study of law should not surprise anyone, because it is but the natural consequence of the aspiration of a people for liberty and justice, a desire increased by contact with another people who, by their temperament and by their traditions, are free and just. The same spirit was prevalent in the thirteen colonies about the time of the Declaration of Independence. This fact was commented upon by Burke in his speech on "Conciliation" delivered before the Parliament.

"The mission of the University does not end with the development of the faculties of medicine and law; it should extend its influence to other phases of life. The most pressing need of the Philippines as a nation is to preserve its existence, without which no further accomplishment can be attained. Our extensive fields, our forests, our mines, and other gifts which nature has liberally deposited in our soil constitute an immense treasure which the intellectual power and industry of man should discover. The only thing necessary is ability to discover ways and means whereby they may be transformed and thus applied to the betterment of human conditions. But discovery is impossible for a people ignorant of the sciences. Knowledge of the laws governing the physical world places in our hands the means of utilizing for our own benefit our natural resources—now diverting the courses of rivers and directing their current to fertilize our fields; now eradicating the diseases of plants and animals to improve and insure our agricultural products; now improving the species of the one and the other through artificial selection to render the labor of man most productive. We should search the bowels of the earth to unfold its hidden treasures. We should transform raw materials to increase their commercial value. Science, in its various aspects, renders almost unlimited the power of human efforts.

"If the University of the Philippines is to realize the object of her foundation, she should produce men able to apply, perhaps to discover, the laws governing the physical world, and through their intellectual power to subdue Nature and to draw out her secrets, from the possession of which humanity derives countless benefits. The University has already done something in this

respect. The students of the College of Agriculture in their scientific study of the cultivation of tobacco (and other economic plants, such as coffee, cocoa, coconuts) have accomplished results which, according to the statement of the manager of a large cigar factory in Manila—are bound to revolutionize the tobacco industry in the Islands; for the possibility of producing fine wrappers such as those imported from Sumatra is now scientifically demonstrated. And the value of these investigations will increase as our graduates are placed in positions to direct and manage farms and plantations all over the Islands.

"In the present state of civilization, the most progressive countries have come to recognize that practice itself cannot be truly practical unless it is also thoroughly scientific. Science is nothing more than the systematized knowledge of facts, and therefore should be the source, the beginning of the most efficient practice. Scientific investigations have modified deeply and fundamentally agriculture in Europe, America, India, and Japan. To see the difference between the efficiency of antiquated agricultural practices and that of modern scientific methods, we need but remember the fact that, according to official reports for 1913, any given area of rice land in the Philippines only produces one-tenth as much grain as an equivalent area in Spain, one-third of the returns in the United States and India, and one-fifth of the production in Japan. This shows again the need of the study of the sciences for the utilization of our natural resources. Closely related to the scientific study of agriculture is the study of the means of avoiding the imminent dangers to the same—drought, locusts, and rinderpest. The University of the Philippines, interested as it is in the prosperity of the country, hopes to turn out agricultural engineers, entomologists, and veterinarians who will, with their knowledge, lend aid in the curbing of such destructive enemies.

"The University should have an annual endowment sufficient not only to insure its existence, but also to provide for its development. A building for the laboratory of the College of Engineering, gymnasium for physical training, and a central auditorium are insistent needs of the University. We need to erect "Rizal Hall" for the class-

rooms and laboratories of zoology, botany, and physics and for the museum and library of these departments. I mention "Rizal Hall," as the construction of this building has already been authorized by the Legislature, its plans and specifications having been prepared and approved by the Board of Regents. We need to enlarge our lands for the experiments of the College of Agriculture. We should also organize new departments and courses as the needs of the University may warrant.

"Thus, with an earnest student body, a

faculty of recognized efficiency, an enthusiastic Board of Regents and Board of Visitors, and equipment adequate to the demand of modern education, the University of the Philippines will accomplish the high purpose which the Philippine Legislature contemplated in establishing the institution—to make this educational center the faithful depository of the glorious heritage of the past, the firm foundation of the achievements of the present, and the vigilant fore-runner of the blessings of the future."

THE FARMERS' CONVENTION AND THE COLLEGE OF AGRICULTURE

The Farmers' Congress recently held in the city of Manila, having for its object the consideration of agricultural matters, had naturally to take into account an institution whose purpose is the training of scientific farmers. On the fourth day of its session, the Acting Dean of the College of Agriculture addressed the delegates on the subject Agricultural Education. Mr. Inocencio Elayda, instructor in Agronomy, also spoke before the Congress on the application, of science to Philippine farming.

On the fifth day of the meeting some sixty members of the Assembly visited the College of Agriculture at the invitation of University President Villamor. After visiting the

various departments of the College, the visitors met the Student Body in the Auditorium where a short program was rendered. Professor Charles S. Banks and Mr. Mariano Gutierrez spoke on behalf of the faculty and student body respectively. Mr. Gervasio Unson, delegate from Tayabas, and Chairman of the Farmers' Assembly Committee on Resolutions, responded for the farmers. He said, among other things, that the visitors saw that the Institution lacked equipment and buildings, and he promised to exert all his influence, with the help of his colleagues, to persuade the Philippine Legislature, at its coming session, to provide more funds for the College.

ACKNOWLEDGMENT.

Through an oversight the following paragraph was omitted from the article "Sugar Manufacture at the Calamba Sugar Estate", published in our last issue:—

"The writer wishes to express his indebtedness to Mr. Norman G. Campion, formerly chief-engineer, and now manager of the Calamba Sugar Estate, for a large part of the information here given concerning the types of machinery in use; to Mr. Hans Doden, assistant manager of the estate, for information concerning the area of the estate and the methods of cultivation employed; and especially to Mr. Frank E. Greenfield, who not only instructed the writer in the various processes of sugar manufacture, but read and corrected the manuscript of this paper."